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Critical differences between typical arc magmas and giant porphyry systems

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Porphyry deposits are the world's most significant source of Cu and an important source of Au. These deposits are intimately associated with arc magmatism and their ore-forming magmas generally follow the typical arc magma differentiation processes. However, most arc magmas are barren and giant economic porphyry Cu ± Au deposits are rare. The critical factors that control the formation of giant porphyry systems in magmatic arcs remain unclear. In this study, we compile rare earth element (REE) concentrations in the typical arc magmas and those of giant porphyry Cu ± Au systems to quantitatively model the proportion of the fractionating minerals required to produce the variations in REE. We show that the ore-associated magmas, in both thick and thin crusts, fractionate more amphibole and less plagioclase than the averages of the thick and thin arc magma systems (the reference suites), respectively, during the andesitic stage of fractionation. These suggest that the ore-producing magmas are more hydrous than average arc magmas. Our model also shows that more amphibole is required to reproduce the REE patterns of the andesite stage of fractionation in the thick-crust reference suite than in its thin-crust equivalents, suggesting that magmas traversing thick crusts are wetter than those traversing thin crusts. On the other hand, the chalcophile element contents of the ore-forming magmas in thin crusts are higher than those of the thick crusts. The high water and moderate chalcophile element contents of the thick-crust ore-forming magmas result in the formation of giant porphyry Cu ores. In contrast, high water and high chalcophile element contents are required to form giant Cu-Au porphyry deposits in thin crusts.

Higher amphibole fractionation in giant economic porphyry suites, compared with their equivalent reference suites, results in lower Y in the ore-associated suites. As a consequence, plots of Y against MgO can be used to identify porphyries with economic potential.